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Experiments on Suspended Cultivation of Mussels in Scotland

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Introduction

There is a great demand for mussels *Mytilus edulis* L. for human consumption in Britain. They are gathered and cultivated in England and Wales, but in order to satisfy the demand something like 1,200 tonnes are imported each year. Mussels are common round the Scottish coasts and indeed large quantities were gathered for use as bait in line fishing at the end of the 19th century, but this declined with the decrease in line fishing and the quantities gathered are now small. Generally speaking, the quality of shore mussels is at best only just good enough for the human market and often it is very poor through overcrowding, long exposure between tides, silty water or other unfavourable conditions. Usually the beds consist of blue-black mussels with rounded edges indicating slow growth. These are in marked contrast to the brown sharp-edged shells and plump flesh of fast-growing mussels.

Mussels are low in the food web, feeding directly on the primary producers, phytoplankton and bacteria and non-living organic material. They are efficient converters and so lend themselves well to cultivation, producing greater yields per unit area than species at higher trophic levels (Ryther and Bardach, 1968). Furthermore, sessile animals such as the mussel are easy to harvest and therefore require less capital investment for equipment, buildings and space than motile species. The various methods of cultivating mussels at present in use have recently been reviewed by Mason (1972, 1976). Cultivation on ropes suspended in the water has long been carried out in southern Europe and a flourishing industry based on this method has arisen on the Galician coast of north-west Spain, where several thousand rafts from which ropes are suspended are anchored in the rias (river valleys which have become flooded by the sea). Cultivation on suspended ropes has a number of advantages over other methods. It is simple; it takes advantage of the phytoplankton on which the mussels feed at all depths in the water and not only on the sea bed; and the mussels are covered by water at all times and not only when the tide is in, so that they are able to feed longer. In addition they are isolated from predators on the sea bed (eg starfish and crabs) and there is less chance of bombardment of the mussels by silt than on the bottom and so the growth rate is enhanced.

The Spanish rias have high temperatures and high phytoplankton production, which result in good growth and fattening of mussels. The sea temperatures in more northern latitudes are generally lower, and in Scotland the most suitable conditions, where the temperature rises above that of the open sea in the summer, occur in certain sheltered inlets on the west coast. The west coast has the added advantage that it offers large areas of clean, unpolluted waters almost entirely free from pests, parasites and diseases of molluscs.

Preliminary Experiments in Loch Thuirnaig

Preliminary experiments to obtain experience of mussel cultivation on ropes were carried out in Loch Thuirnaig, an arm of Loch Ewe, Wester Ross, not because the conditions are especially favourable there, but because research facilities were available at the nearby field station on Loch Ewe. Loch Thuirnaig (Fig. 1) is sheltered, with no wide variations in salinity, and good quality mussels are found on the shore.

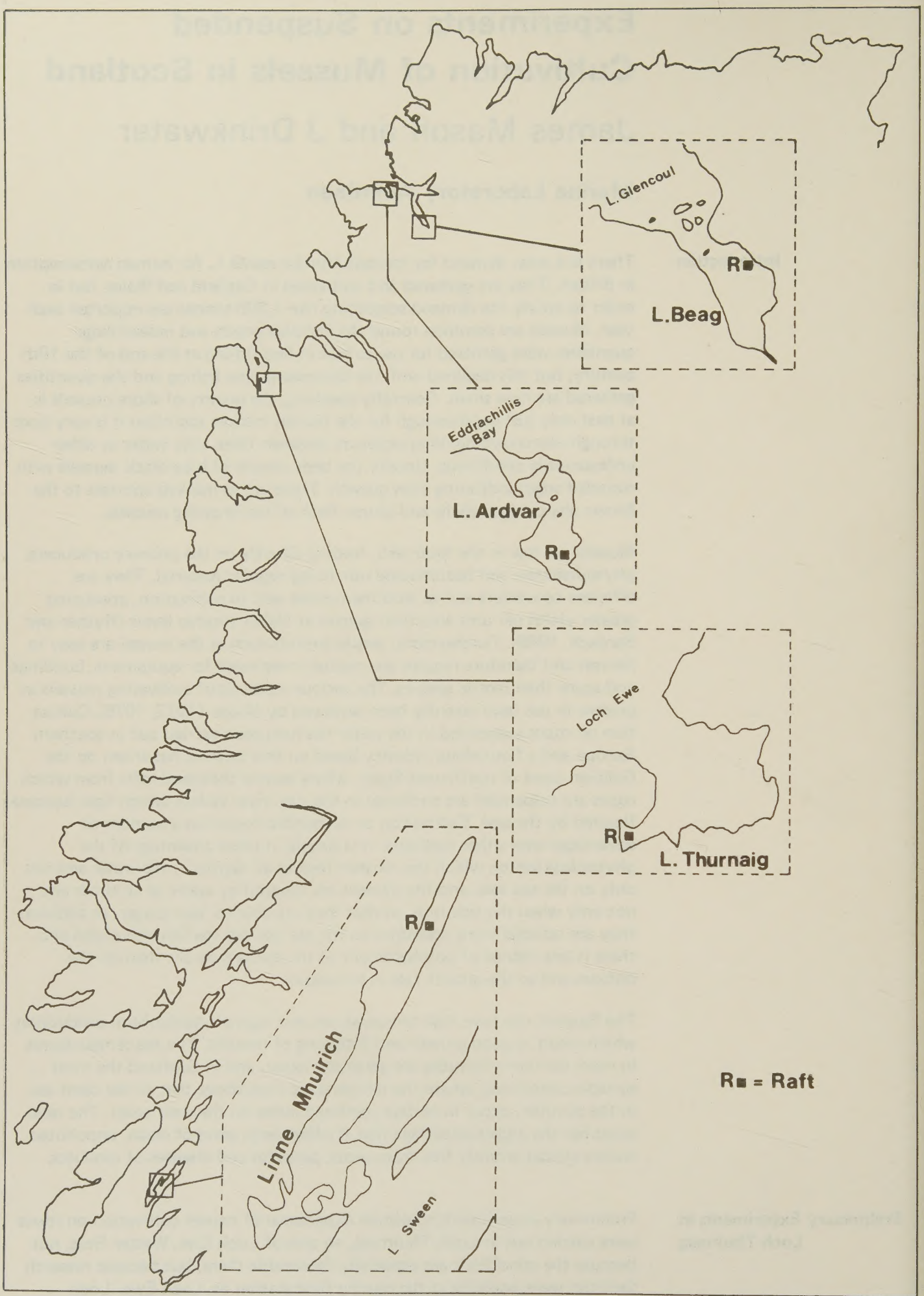


Figure 1. Map showing sites of experiments.

Sisal ropes, 3 m long and 20 mm in diameter, were hung from buoyed headlines in March 1966. Ropes and anchor ropes soon collected a film of brown filamentous algae. By July 1966 there was a dense spatfall of mussels (mean length 0.9 mm), which had reached 42.2 mm by September 1967 and 61.6 mm by September 1968. Further ropes put out in February 1967 had a very dense spatfall by July of that year. Their mean length was 1.0 mm and there were over 13,000 individuals on a 20 cm sample length of rope. By April 1969 the mean length was 50.3 mm but the numbers had fallen to only 55 per 20 cm of rope. There were very few individuals from later settlements among these mussels. At the end of the experiments in January 1970 one of the original anchor ropes was found to be carrying mussels, presumably settled in 1966, which had a mean length of 76.4 mm and a density of 53 per 20 cm length of rope.

In May 1966 small shore mussels were bound onto a rope using open mesh muslin which soon decayed after the ropes were hung. The mussels remained attached to the rope by the byssus. The mean length of the mussels rose from 31.4 mm at the start of the experiment to 62.3 mm by September 1968.

Condition factors (volume of blotted raw meat as a percentage of total internal volume: Baird, 1958) were measured for both shore and suspended mussels. In shore mussels values ranged from 26% to 41%. Rope-grown mussels were considerably better, with condition factors ranging from 38% to 59% and giving yields of cooked meat (as a percentage of total weight) of 17-28%.

These results suggest that it is possible to grow good quality mussels to a commercial size (50-60 mm) in a little over two years from settlement, considerably faster than rates recorded previously for naturally-growing mussels in Britain (Table 1). This was sufficiently encouraging to justify setting up experiments at other sites.

Table I

Comparison of Mussel Growth Rates

Locality	Method of Growth	Growth rate	Authority
Galicia (Spain)	Ropes	70 mm in 1 year 80 mm in 14 months	(Andreu, 1958)
Linne Mhuirich (Scotland)	Ropes	61 mm in 1 year 67 mm in 14 months	(Present paper)
Loch Thuirnaig (Scotland)	Ropes	62 mm in 26 months	
Loch Beag (Scotland)	Ropes	60 mm in 26 months	
Oslo Fjord (Norway)	Ropes	60-70 mm in 18 months	(Bøhle & Wiborg, 1967)
Zuiderzee (Holland)	Bed	72 mm in 3 years	
Wash (England)	Bed	54 mm in 3 years	(Quoted by
Aiguillon (France)	Bouchot	40 mm in 2 years	Andreu, 1958)
Conway (Wales)	Bed	61 mm in 5 years	

Linne Mhuirich

Linne Mhuirich, Argyll, was chosen as the site for the main experiments because conditions there were known to favour growth, fattening and breeding of another filter feeding bivalve, the European flat oyster *Ostrea edulis* L. (Miller, 1961). The experiments were carried out by kind permission of Mr T.P. Stevenson, who held the oyster and mussel fishing rights. Linne Mhuirich (Fig. 1) is a sheltered inlet 4.4 km long and up to 0.4 km wide. The depth is mostly less than 3 m with a maximum of only 13 m. The part used for the experiments was 4 m deep. The inlet is separated from Loch Sween by a narrow entrance with a shallow sill. The tidal range is only 0.6 to 0.9 m. There is little fresh water inflow and summer temperatures are high.

Environmental conditions

Water samples were taken at approximately monthly intervals and in addition a recording thermograph on one of the experimental rafts was used to measure the temperature at the surface and at a depth of 2 m. Temperature variation was greater than in the neighbouring open sea. It tended to follow more closely the air temperature. In winter the temperature at 2 m fell to below 3° C but in summer it approached 20° C (Fig. 2). Salinity was mostly between 30 and 33‰ and even after periods of heavy rain never fell lower than 25‰ (Fig. 3). Chlorophyll and total carbon levels were generally much the same as in other west coast lochs, ranging from 0.5 to 3.5 mg chlorophyll per m^3 and 120 to 570 mg carbon per m^3.

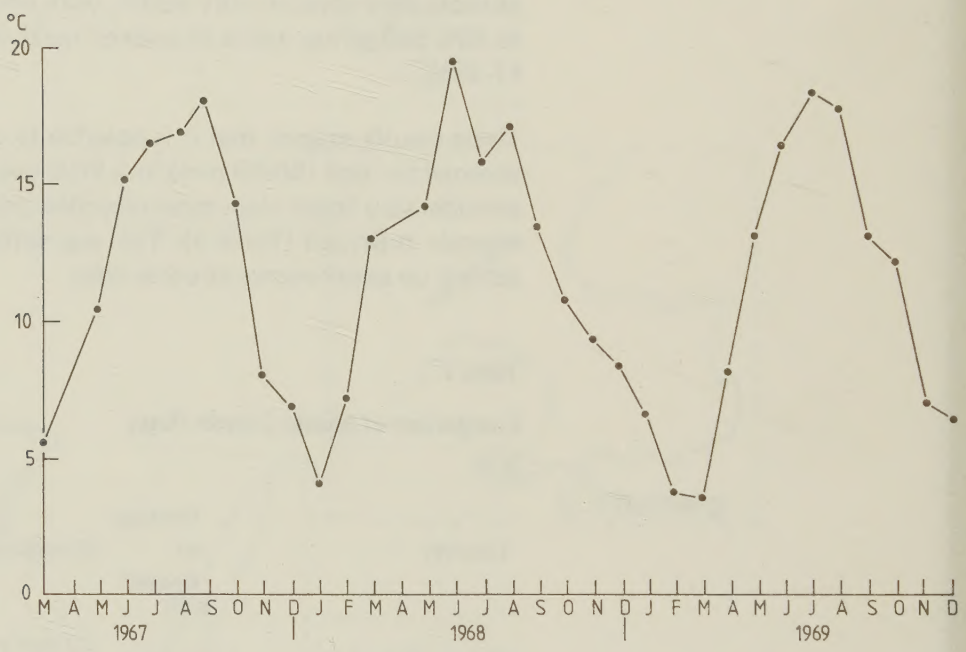


Figure 2. Temperature at 2 m in Linne Mhuirich.

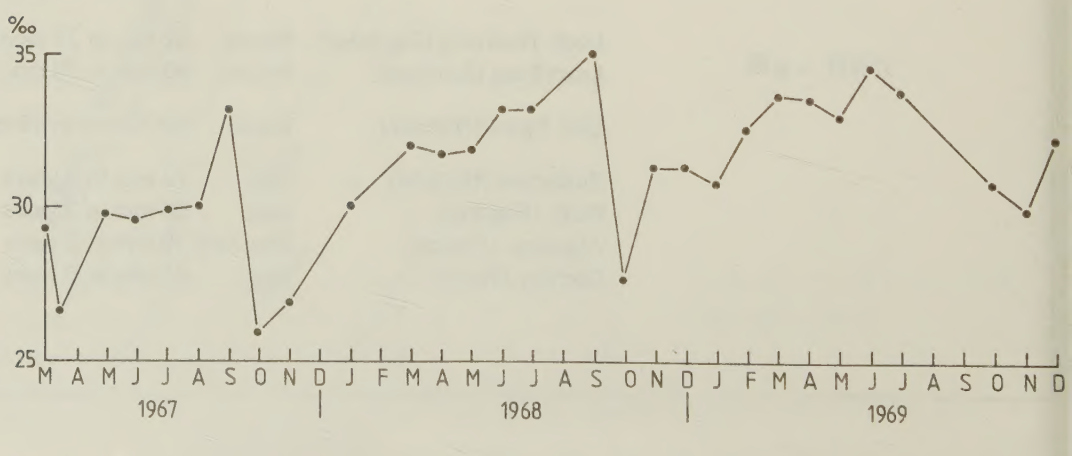


Figure 3. Salinity at 2 m in Linne Mhuirich.

Settlement

Plankton samples were taken at approximately monthly intervals with a ½ m net of mesh size 68 μm. The net was towed for 20 minutes over a standard course. The samples were diluted to 400 ml, agitated thoroughly and 5 ml were drawn off with a Stempel pipette for detailed examination. The number of D-shaped and later bivalve larvae were counted. As no other species of bivalves were present in appreciable numbers in Linne Mhuirich it was assumed that all these larvae were mussels. The results are shown in Figure 4. To study settlement from March 1967 to October 1969, four sisal ropes 3 m long were hung from buoyed headlines at approximately monthly intervals. During 1967 they were left for periods of one month, but subsequently for two months. Figure 4 shows the mean numbers of spat settled.

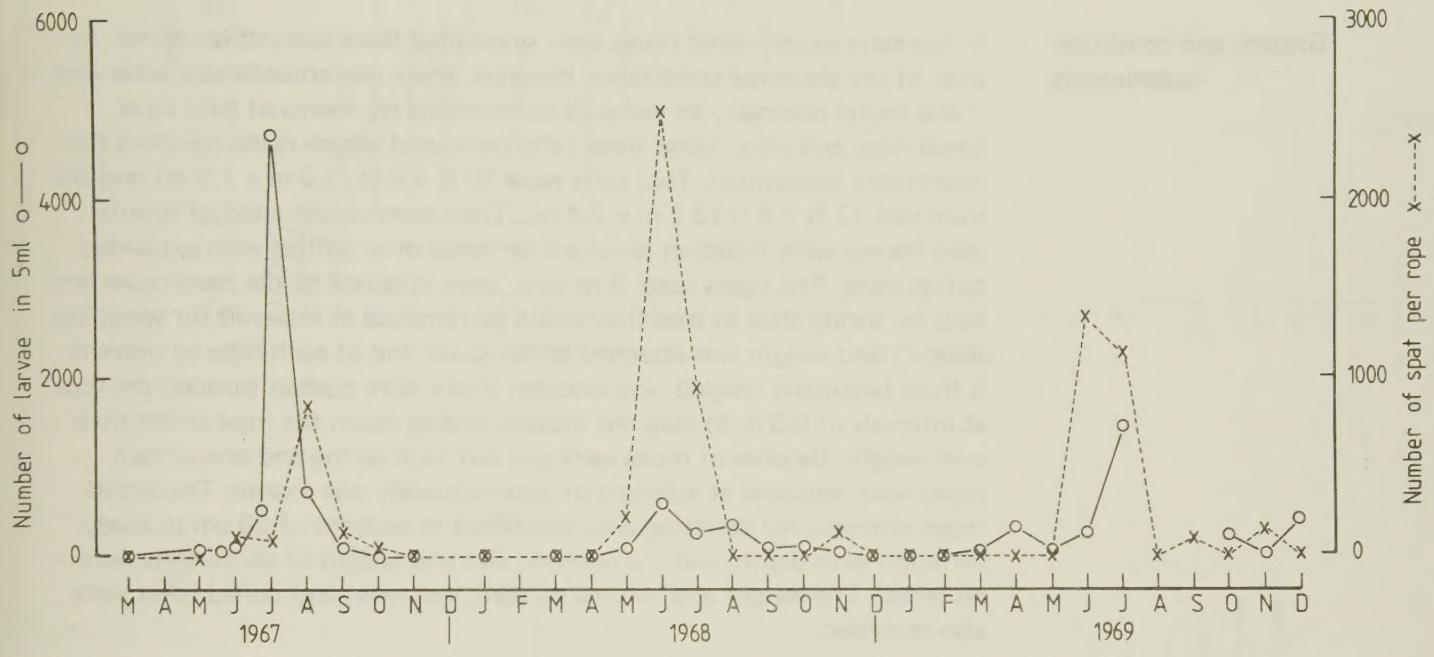

6000
4000
2000
0
Number of larvae in 5ml o—o
3000
2000
1000
0
Number of spat per rope x---x
M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1967
1968
1969

Figure 4. Seasonal abundance of larvae and settlement on ropes.

There is a close relationship between numbers of larvae in the plankton and numbers settling. In 1967 spat were first seen in June and settlement reached a peak in July or August, after which it fell away and had virtually ceased by October. In 1968 and 1969 settlement reached a large peak in June, after which it fell away almost completely, though there was a small amount of settlement in the autumn. The peak settlement of 1967 was the smallest in any of the three years, both in absolute numbers and relative to the numbers of larvae in the plankton. This might to some extent be accounted for by the shorter immersion period of the ropes in 1967.

Sixteen ropes, four each of four different kinds, 20 mm courlene, 20 mm coir, 20 mm sisal and 8 mm sisal were compared as to their suitability for settlement. This was shown by the weights of the ropes and contents in water, the increase in weight being attributable almost entirely to mussels. The most abundant settlement occurred on coir, the roughest rope, and the least abundant on courlene, the smoothest (Table II). The primary settlement of spat occurred on hydroids and filamentous algae on the ropes as well as on the rope fibres, so that the prior settlement of these provides additional substratum for the settlement of mussels. Ropes stretched horizontally and vertically in suspended metal frames alike acquired a dense settlement of spat, as indeed did the frames themselves together with the headlines and floats.

Table II

Mean Increase in Weight of Ropes in Water Attributable to Mussels, 21st July-23rd September, 1967

Rope	Increase (kg)
20 mm coir	2.60
20 mm sisal	2.19
8 mm sisal	1.43
20 mm courlene	1.37

Growth and condition experiments

In the early experiments ropes were suspended from buoyed headlines. In spite of the sheltered conditions, however, there was considerable wear and it was found necessary to make all connections by means of hard eyes, metal rings and clips. Later three rafts were used which made handling the ropes more convenient. Two rafts were 10 ft x 6 ft (3.0 m x 1.8 m) and the third was 12 ft x 8 ft (3.7 m x 2.4 m). They were constructed of tubular steel frames with flotation provided by metal drums filled with expanded polystyrene. The ropes used, 3 m long, were attached to the head ropes and rafts by spring clips so that they could be removed at intervals for weighing. A small lead weight was attached at the lower end of each rope to prevent it from becoming tangled, and wooden sticks were pushed through the rope at intervals of 0.5 m to stop the mussels sliding down the rope under their own weight. Batches of ropes were put out each spring and one or two ropes were removed at intervals of approximately one month. The whole ropes removed for sampling were examined in sections of 20 cm to study variation with depth, and the number, size and weight of all mussels were recorded. The weight and volume of shell, wet meat and boiled meat were also recorded.

Growth

It was possible from the monthly length frequency data to identify the mussels from each main settlement and to separate them from those that settled among them later. An example is shown in Figure 5.

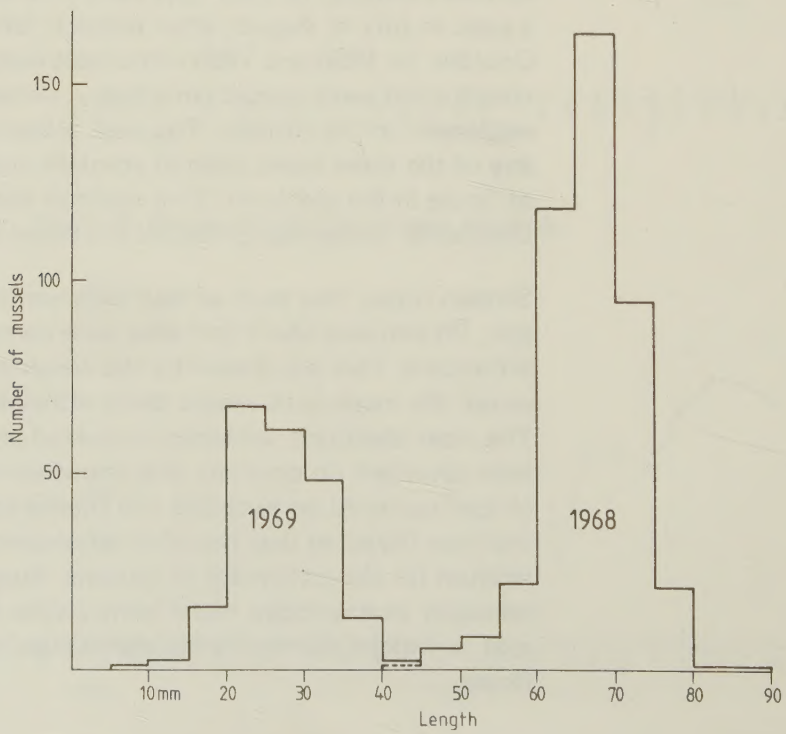
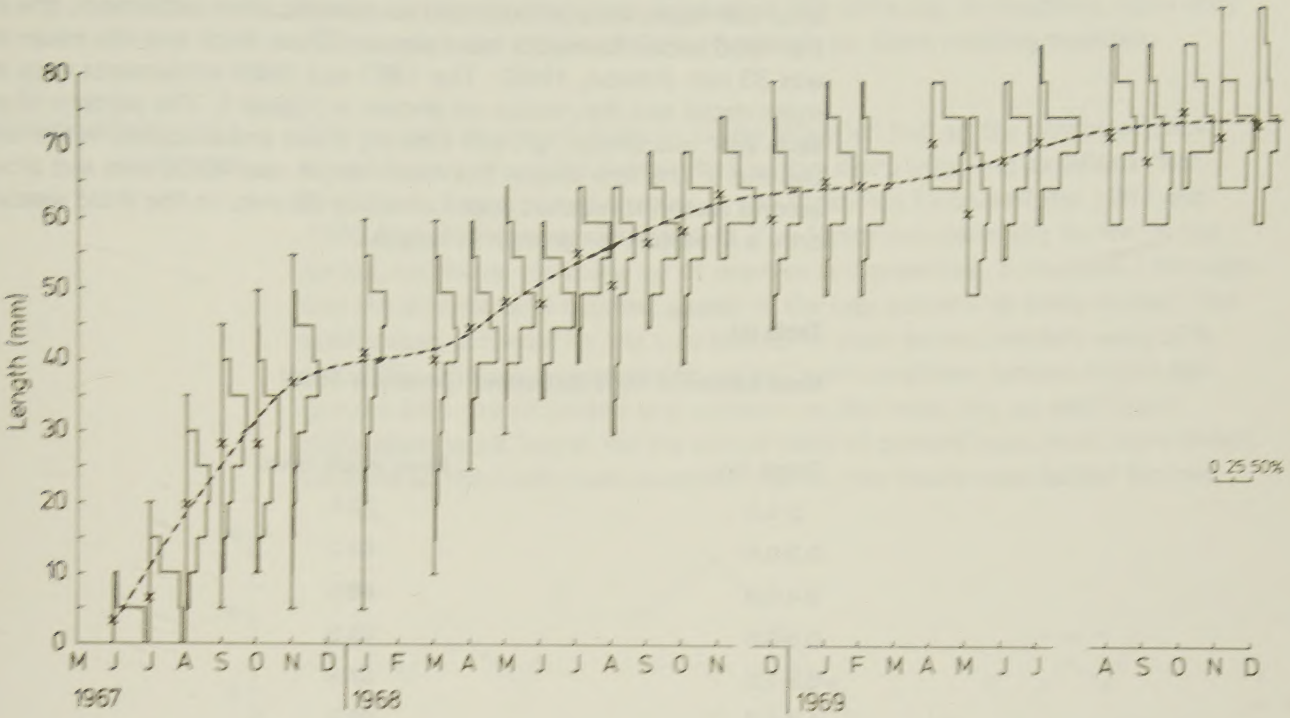


Figure 5. Method of separating year groups.



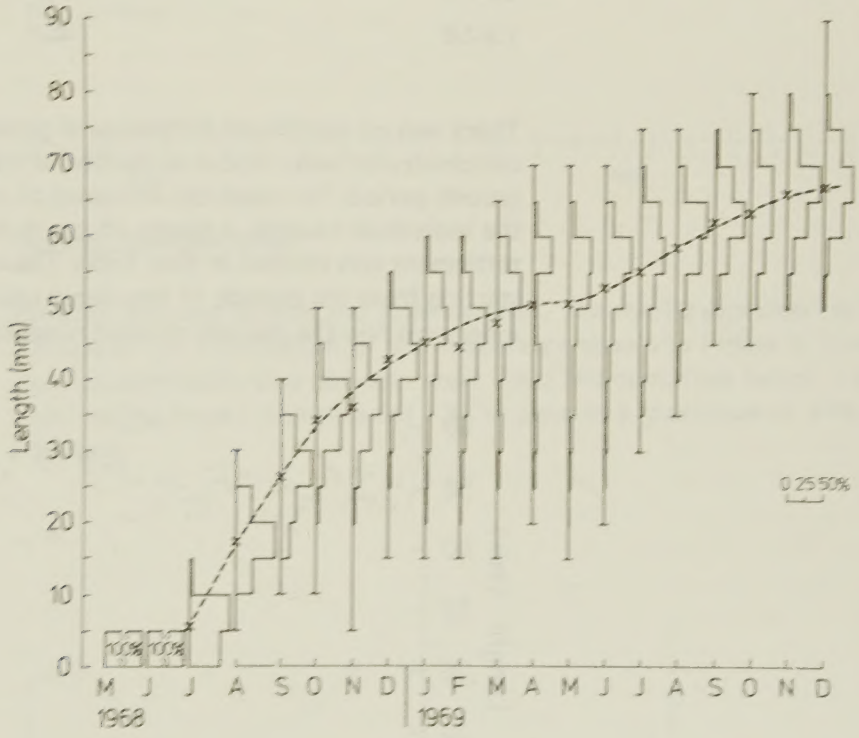


Figure 6. (a) Growth in Linne Mhuirich – 1967 settlement
(b) Growth in Linne Mhuirich – 1968 settlement.

Growth of mussels was rapid in the first summer and early autumn, but slowed down or stopped during the winter. It speeded up in the second spring and again slowed down in the autumn. By January 1967, eight months after the ropes were put out and six months after settlement, the mussels of the 1966 brood formed a mass almost 30 cm thick and the mean shell length was 33 mm (Mason, 1968). The 1967 and 1968 settlements were studied in more detail and the results are shown in Figure 6. The pattern of growth each year was similar, growth slowing down and stopping in the winter. At the end of the first season the mean length was 40-50 mm and after the second season it reached approximately 65 mm. In the third season there was only a little further growth in length.

Table III

Mean Length of 1968 Settlement (December 1969)

Depth (m)	Mean length (mm)
0-0.2	67.1
0.2-0.4	66.2
0.4-0.6	66.5
0.6-0.8	69.5
0.8-1.0	67.8
1.0-1.2	62.0
1.2-1.4	67.3
1.4-1.6	68.3
1.6-1.8	68.1
1.8-2.0	65.4

There was no significant difference in growth with depth. Table III shows that uniformity of mean size at all depths of mussels at the end of their second growth period. To assess the influence of crowding on the growth rate of the individual mussels, a clump 16 cm in diameter of mussels from the 1967 settlement was studied in May 1968. The mussels were measured individually starting from the outside of the clump and working inwards. Apart from the innermost few the mussels showed remarkable uniformity in size (Fig. 7).

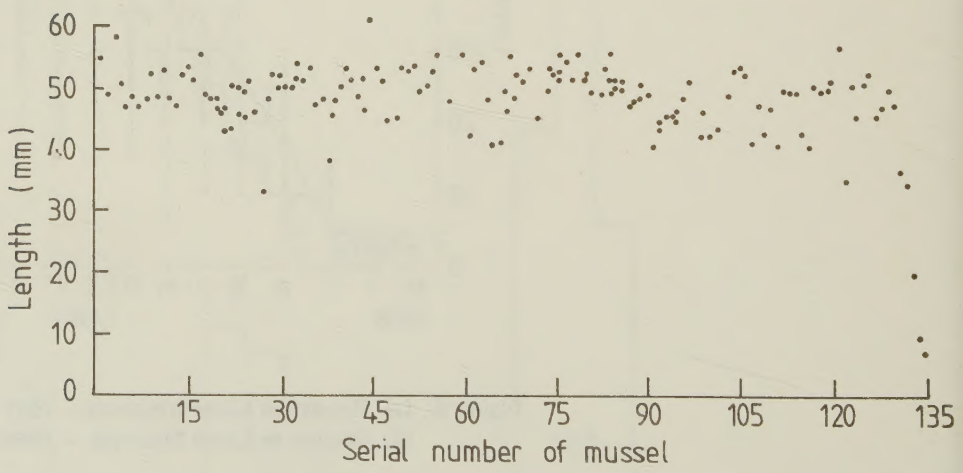


Figure 7. Size of mussels from outside to inside of clump.

The effect of distance between ropes on the settlement and growth of mussels was assessed by comparing the weights of mussels on the inner members of two sets of ropes, one 30 cm apart and the other 60 cm apart

Little difference was detected in the weight of the mussels from the June 1967 settlement; in November 1967 the mean weight on ropes 30 cm apart was 5.1 kg and on ropes 60 cm apart 5.6 kg. The experiment was not continued beyond this date because of the difficulty in handling ropes only 30 cm apart and the possibility of mussels on them rubbing together.

Condition factor and meat yield

The mussels grown on ropes in Linne Mhuirich had all the characteristics of quick growth, a thin brown shell with a sharp edge and excellent flesh condition. The seasonal changes in the condition factors of the 1967 and 1968 groups are shown in Figure 8. The factor was generally lowest in the spring, following the using up of reserves and spawning. It increased throughout the summer and reached a peak in the late autumn or early winter. The peak values achieved by the two broods in their second winters were 57% and 55%. A check was made for variation of condition factors within age groups with size of mussel and position on the rope, but no significant differences were found. As the actual yield of cooked meat is of more direct concern to the trade than condition factor, the meats were boiled for two

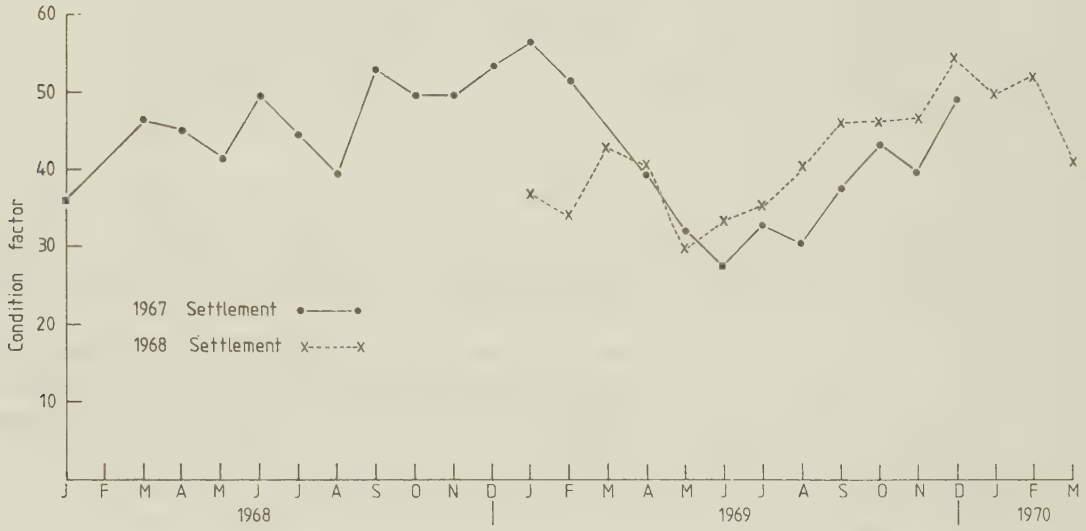


Figure 8. Condition factor.

minutes, allowed to cool and then weighed. The results expressed as a percentage of the total weight of the mussels are shown in Figure 9. There is a clear direct relationship between meat yield and condition factor. The meat yield ranged from a minimum of 13% in June to a maximum of 24% in February.

Figure 9. Condition factor and meat yield.

There was considerable variation in total yield between individual ropes, owing to differential survival of mussels. In order to avoid disturbing mussels, with consequent losses from the ropes, the ropes were weighed in water. The ropes which were removed monthly were also weighed in air. The weight of a rope and contents in air was almost exactly four times the weight in water (Fig. 10). The weights in air could thus be computed from the weights in water, the weight of mussels arrived at by subtracting the

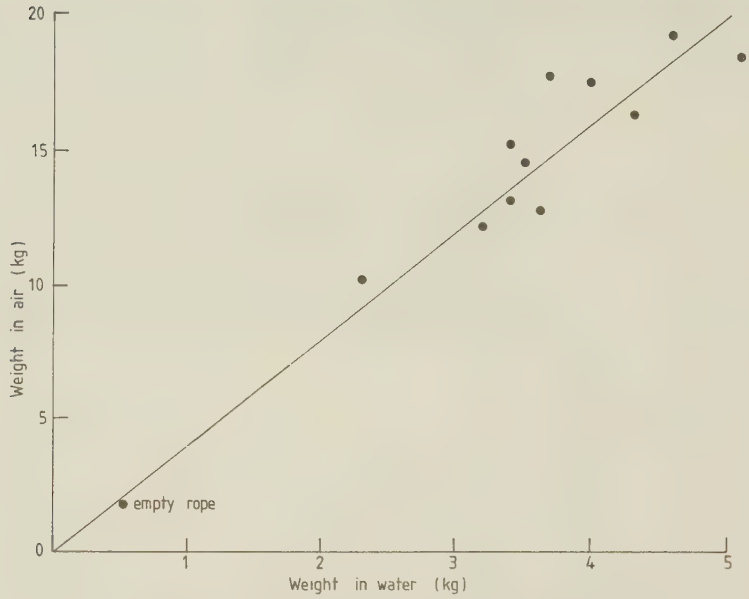


Figure 10. Relation between weight in air and weight in water.

weight of the rope, and the total weight of meat calculated using the meat yield data (Fig. 11). There was a loss of mussels over the winter which, combined with the poorer condition factors in the summer, meant that there

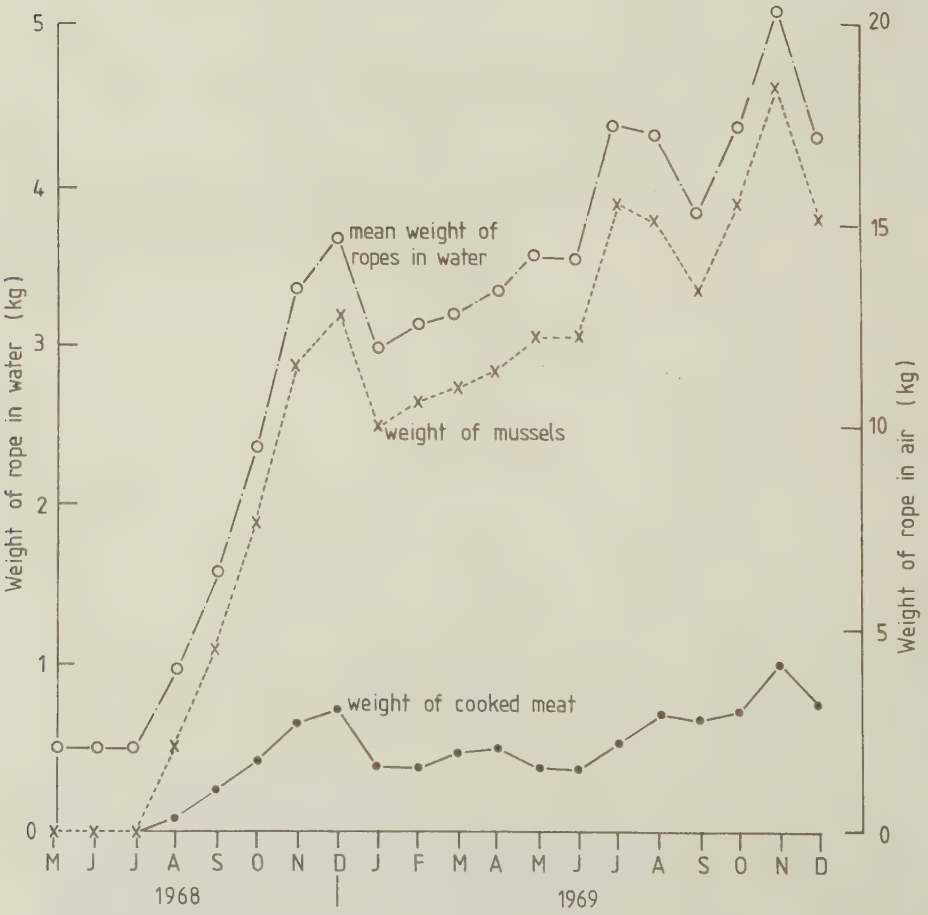

Weight of rope in water (kg)
Weight of rope in air (kg)
mean weight of ropes in water
weight of mussels
weight of cooked meat
M J J A S O N D J F M A M J J A S O N D
1968
1969

Figure 11. Weight in water, in air and meat yield.

was a long period in the second growing season before the yield was as high as at the end of the first season. The yield of mussels late in the second growth period thus reached a maximum of 18.5 kg per rope and the corresponding maximum yield of cooked meat was 4.1 kg per rope.

Predators and Competitors

Ascidians of the genera *Ciona* and *Ascidiella* settled on all apparatus deeper than about 1 m. They appeared to have little effect on well established mussels. However, they became dense on ropes put out after the main mussel settlement and prevented settlement of mussels from taking place later when subsidiary settlements were taking place on clean ropes.

It was found possible to kill the softer-bodied *Ciona* by leaving it exposed to air overnight. The harder *Ascidiella* proved more difficult to kill. Ropes bearing mussels and *Ascidiella* were exposed to the air for 6 hours in daylight in November and then replaced in the water. Four days later, approximately one third of the *Ascidiella* were wrinkled and dead, while the mussels appeared to be unaffected. Tube worms (*Pomatoceros* and serpulids) settled in the early spring. *Pomatoceros* settled mainly on the mussel shells themselves but serpulids mainly on the bare patches of rope, particularly towards the bottom. The tube worms did not appear to affect the mussels biologically but the sharpness of their tubes made handling the ropes difficult.

In April 1968 considerable damage to the experimental ropes was discovered (Dunthorn, 1971). This was attributed to eider ducks diving and stripping mussels from the ropes. Subsequently ropes were protected by curtains of netting hanging from the rafts which successfully prevented further predation by the ducks.

Experiments in Sutherland

After the success of experiments in Linne Mhuirich, further experiments were started to find out whether other areas on the west coast of Scotland would be suitable for mussel cultivation. Interest had been shown in parts of the coast of Sutherland, where good quality mussels had been found growing on mooring buoys, and so two lochs were chosen in that area. These were Loch Beag and Loch Ardvar (Fig. 1). The experiments were broadly similar to those in Linne Mhuirich but visits were limited to intervals of about 3 months. Rafts were moored in the two lochs in March 1970 and observations continued until March 1973.

Loch Beag

This sheltered loch lies at the head of Loch Glencoul, part of the Loch Cairnbaan group (Craig, 1954; Milne, 1972). There is a sill between Loch Beag and Loch Glencoul and further sills at Kylestrome and at the entrance to Loch Cairnbaan. An experimental raft was moored on the north side of Loch Beag in a depth of 6.5 m. Temperatures near the surface ranged from 5.8° C in March 1972 to 14.5° C in July 1971. Salinity was mostly within the range 29-33‰, although after periods of heavy rain there was a thin surface layer of much lower salinity, the minimum recorded being 16.7‰ in March 1973. Sisal ropes 3 m long were hung in March and May 1970 and examined on subsequent visits. By July 1970 there was a dense settlement of mussels on all ropes. They grew slowly during the remainder of 1970, attaining a mean size of only 5.2 mm by January 1971. Subsequent growth was comparable to that in Loch Thuirnaig. By December 1971 the mean size had reached 45.5 mm and by September 1972 60.0 mm (Fig. 12). In addition to the main settlement in the summer of 1970, there was a subsequent settlement which first showed itself in April 1971 and presumably originated from a spawning in the autumn or winter of 1970. It was subsequently possible to distinguish between the mussels from the two settlements by their length frequency distributions. Samples for growth studies were

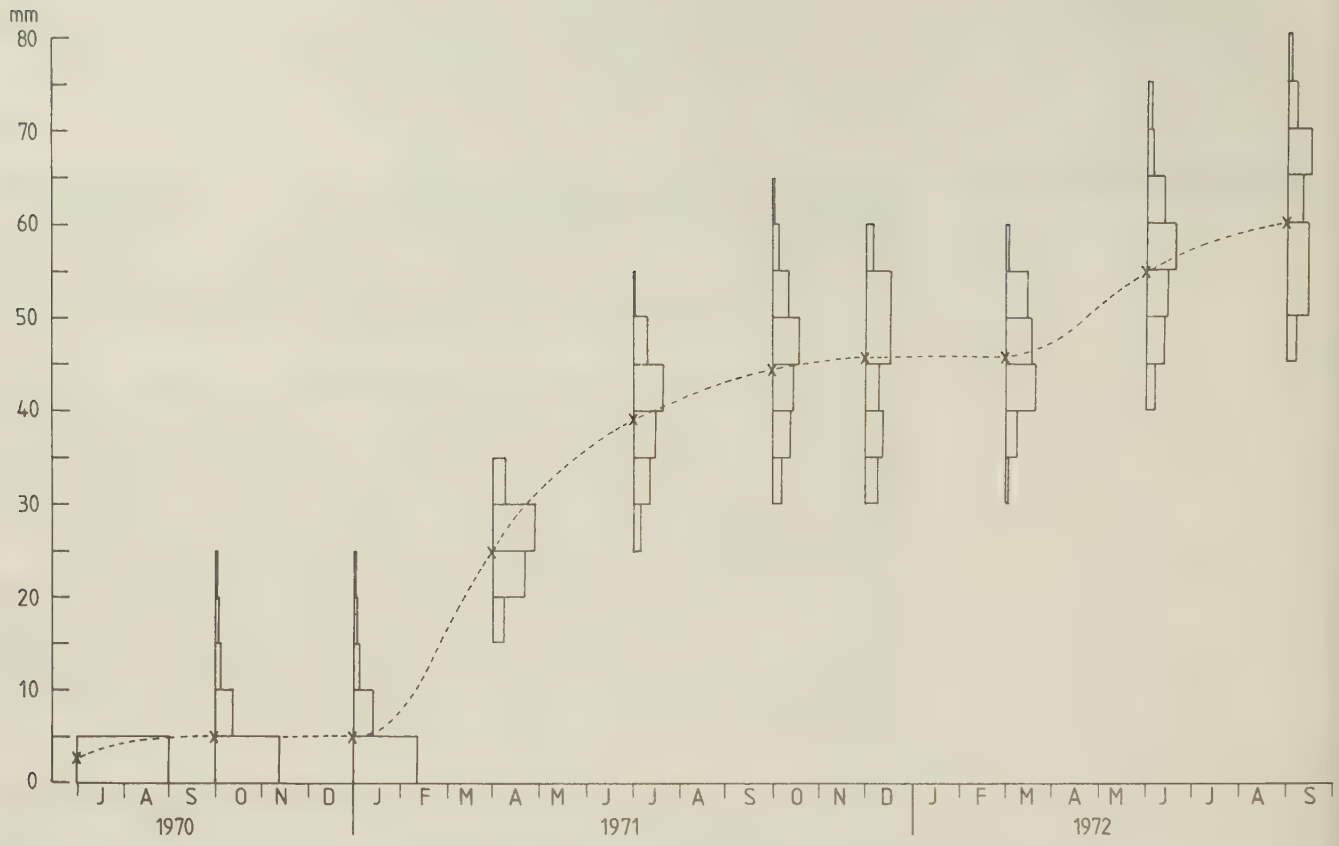


Figure 12. Growth in Loch Beag.

taken from below 1 m because the mussels on the upper part of the rope were considerably smaller, probably owing to the reduced salinity. Because of the limited number of visits the seasonal variation in condition factor and meat yield could not be demonstrated in detail. It was, however, possible to show the superiority of raft-grown mussels over those collected low on the shore.

The condition factor of raft-grown mussels ranged from 37% to 53% as compared with 28% to 40% in shore-grown mussels. The corresponding meat yields were 17% to 23% in raft-grown mussels as compared with 8% to 12% in shore mussels. In late 1971, after two growing seasons, the three remaining ropes yielded an average of about 17 kg of mussels, a figure similar to that in Linne Mhuirich after two seasons. Thus the slower growth in Loch Beag is compensated for by superior settlement and/or survival.

Loch Ardvar

The inner basin of this loch was chosen as an experimental site because it appeared to have the characteristics of a good growing area, being well sheltered and separated from the outer basin by a very shallow sill. Naturally growing mussels of good quality were plentiful on the shore. During the period of the experiment temperatures ranged from 6.9° C in January 1971 to 13.5° C in July 1971. Apart from at the mouth of the river, salinities were almost always above 30‰ and were mainly within the range 30-33‰.

A raft was moored in a depth of 3.5 m and sisal ropes 3 m long were hung from it in March 1970. The ropes were examined during subsequent visits at intervals of approximately 3 months and other ropes were put out during these visits. There was no sign of mussel settlement in July. By October the ropes had acquired a covering of red filamentous weed and the ascidian *Ascidiella* was common. A few small mussels were now present. None of the

later ropes, nor those put out in succeeding years, acquired more than a scattering of mussels and it was concluded that Loch Ardvar is a poor settlement area. The few mussels which did settle, however, grew well. Those in a clump measured at the end of 1971 had attained a mean size of 54.9 mm, in a maximum of two growing periods. The quality of mussels on the raft was good, the condition factor ranging from 36% to 59%. The meat yield ranged from 13% to 25% by weight. The natural mussels on the shore also had good flesh, their condition factor ranging from 36% to 48% and the meat yield from 10% to 17%.

Wooden poles and wattle fences erected on the shore at low water springs in April 1970 acquired no settlement of mussels. The wood was quickly destroyed by *Limnoria.*

Transplanting experiments

In order to assess the true potential of Loch Ardvar as an on-growing area, small mussels were transferred there from Loch Beag. As a preliminary test a complete rope from the original Loch Beag experiment was wrapped in a mesh bag and transferred whole to Loch Ardvar in April 1971. The transplanted mussels continued to grow well, so further tests were made using special mesh tubes developed in Norway (Bǿhle, 1970). These consist of strong longitudinal strands with a weaker spiral strand forming the mesh. Small mussels were placed inside a 2 m length of tube and in a few hours had migrated through to the outside. There they remained attached by the byssus, the tube forming a core surrounded by the mussels.

Those transferred to Loch Ardvar, where they were suspended from the raft, in April 1971, grew from a mean length of 13.4 mm then to 55.2 mm at the end of 1971 and 66.3 mm at the end of 1972. This growth rate was higher than that of mussels remaining on ropes in Loch Beag. However, in a further similar experiment started in March 1972, mussels put in tubes and left in Loch Beag grew just as well as other mussels transferred in tubes to Loch Ardvar. Between March 1972 and March 1973 the mussels left in Loch Beag grew from 30.9 mm to 53.6 mm and those transferred to Loch Ardvar reached 52.4 mm.

Discussion

The present experiments have demonstrated the feasibility of suspended cultivation of mussels in various places on the west coast of Scotland. Conditions in Linne Mhuirich are especially favourable for the settlement and rapid growth of mussels and the production of flesh of excellent quality. The growth rate there (Table I) compares favourably with growth rates elsewhere in Europe with the exception of the rias of north-west Spain. The normally accepted commercial size in Britain in 50-60 mm. The results show that it is possible to produce mussels of this size in Linne Mhuirich within 12-14 months of settlement. This involves a 2-year cycle from the time the ropes are put out. There are other suitable areas with similar conditions, especially high summer temperatures, among the many inlets of the west coast. Examples include other inlets of Loch Sween, West Loch Tarbert, Little Loch Roag and Pool Roag (Millar, 1961). In other reasonably sheltered areas, even without particularly high summer temperatures, it should be possible to grow mussels to commercial size (50-60 mm) in two years from settlement, involving a 3-year cycle. By transplanting seed from good settlement areas to areas of good growth it should be possible to produce commercial sized mussels in a single further growing season. In this way mussels transplanted in the early spring would be able to benefit from the spring phytoplankton bloom in the good area.

Since there is less growth after the second autumn mussels grown commercially would be best harvested from then onwards as long as the flesh condition remains high prior to the spring spawning. It should be borne in mind, however, that clumps of mussels which have become heavy by the winter are liable to fall off during the bad weather at this period and should therefore be harvested as early as possible in the winter period.

For certain markets, especially the French, 40-50 mm is an acceptable size. This was attained in one growing season in Linne Mhuirich, and in two seasons in Loch Thuirnaig and Loch Beag, as well as in some other lochs investigated by C.A. Comely (Personal communication). Marketing at this size should be considered as it would avoid the decline in total meat yield caused by losses of mussels during winter and decline in flesh condition during the following spring and summer, and thus save a year's operations.

The west coast of Scotland is capable of producing fast-growing mussels of such good quality that they can be presented as a luxury product. Provided that the costs of labour and installations can be kept down suspended culture could be profitable in many areas. Indeed small scale commercial operations are already under way, producing mussels which fetch a price more than ten times the present average for commercially marketed mussels in the United Kingdom.

Summary

The feasibility of the culture of mussels on ropes was investigated in a number of lochs on the west coast of Scotland. In Linne Mhuirich (Loch Sween) the mussels grew to a commercial size (50-60 mm) in 12-14 months from settlement. In Loch Thuirnaig (Loch Ewe) and Lochs Beag and Ardvar (Sutherland) growth was slower but mussels reached commercial size in 2 years or slightly longer from settlement. Settlement was good in all areas except Loch Ardvar. Mussels were successfully transplanted in netting tubes, suggesting the possibility of obtaining seed from areas of good settlement for on-growing in areas of good growth.

Flesh condition was good in all areas, and the yield of cooked meat was 13 to 28% of total weight, which is much higher than that of naturally occurring mussels on the shore.

The ropes were 3 m long and in Linne Mhuirich yielded a maximum of 18.5 kg of mussels after two growing seasons. Losses were caused by mussels falling off the ropes in bad weather and this resulted in a nett loss in weight in winter. The yield of meat also declined over the winter, remaining low until autumn, when further growth and improvement in condition resulted in an increase in weight. Autumn is thus the best time to harvest mussels for maximum yield.

Marketing of rope-cultivated mussels from the west coast of Scotland has now started and the prospects of expansion appear promising.

References

Andreu, B. 1958. Sobre el cultivo del mejillon en Galicia. Biologia, crecimiento y produccion. *Industrias Pesqueras, Vigo,* No 745-746, 44-47.

Baird, R.H. 1958. Measurement of condition in mussels and oysters. *Journal du Conseil permanent international pour l'Exploration de la Mer* **23**, 249-257.

Bøhle, B. 1970. Forsøk med dyrking av blåskjell (*Mytilus edulis* L.) ved overføring av yngel til nettingstromper. *Fiskets Gang* **56**, 267-271.

Bøhle, B. and Wiborg, K.F. 1967. Forsøk med dyrking av blåskjell. *Fiskets Gang* **24**, 391-395.

Craig, R.E. 1954. A first study of the detailed hydrography of some Scottish west highland sea lochs (Lochs Inchard, Kanaird and the Cairnbaan group). *Annales Biologiques, Copenhagen* **10**, 16-19.

Dunthorn, A.A. 1971. The predation of cultivated mussels by eiders. *Bird Study* **18**, 107-112.

Mason, J. 1968. Cultivation of mussels, *Mytilus edulis* L., in Scotland. International Council for the Exploration of the Sea, CM 1968, Document E:4, 5 pp mimeo.

— 1972. The cultivation of the European mussel, *Mytilus edulis* Linnaeus. *Oceanography and Marine Biology Annual Review* **10**, 437-460.

— 1976. Cultivation. *Bayne, B.L. ed. Marine mussels: their ecology and physiology.* Cambridge, University Press, 385-410.

Millar, R.H. 1961. Scottish oyster investigations, 1946-1958. *Marine Research* 1961 **(3)**, 76 pp.

Milne, P.H. 1972. Hydrography of Scottish West Coast Sea Lochs. *Marine Research* 1972 **(3)**, 50 pp.

Ryther, J.H. and Bardach, J.E. 1968. The status and potential of aquaculture, particularly invertebrate and algae culture, Part I. Washington, US Department of Commerce National Bureau of Standards, 45 pp.

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